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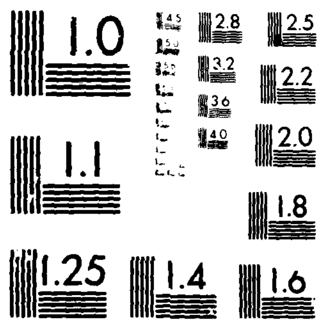

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(SELECTED ARTICLES)

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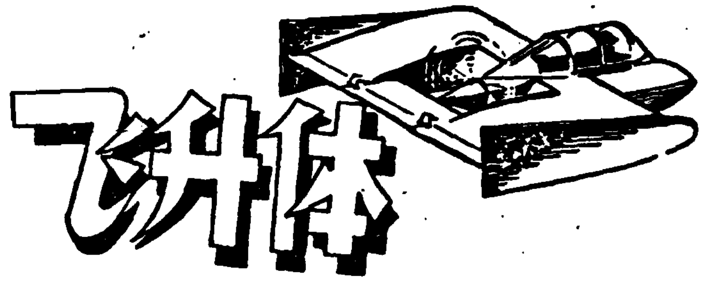
Table of Contents

A Flying Body



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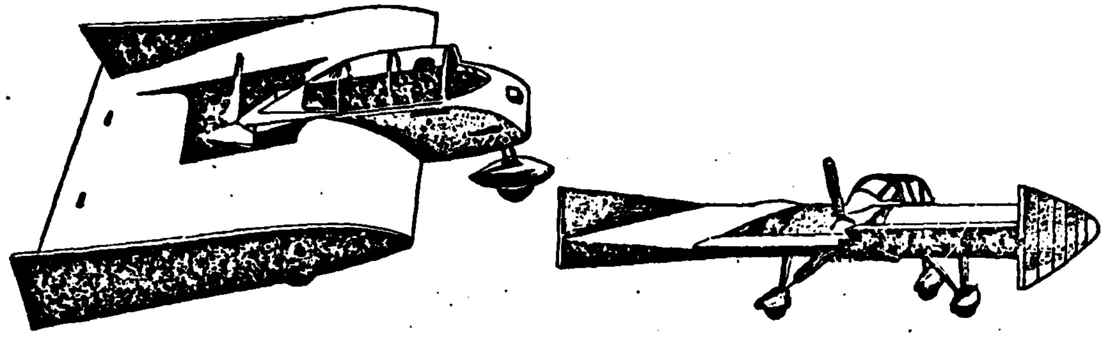
A Brief Overview

When you see the flying body in front of you, what do you think? First, you'd probably be puzzled. As we say, "a bird cannot fly without wings". The flying body in our sight does not have the familiar wings. This is called a wingless airplane abroad. Actually, it is not wingless. Its wings are unusually deep and short, and its cabin and wings form almost a single body. Further, it does not have a rudder that protrudes from the plane body, like the conventional airplanes. Without a rudder, how can the flight be stabilized in air? A closer look at the aircraft will reveal that there is a controllable stabilizer in the rear of this flying body. In addition, on the two wingtips are installed 14-foot (4.26-meter) airfoils which provide directional stability. The propeller is also installed in an unusual position. It is placed at the rear of the cabin-like body.

The flying body can seat two persons, including the pilot. It is eighteen feet (about 5.5 meters) wide and also eighteen feet long (from the tip of the cockpit to the trailing edge), and has a much smaller span-to-chord ratio (see figure below). In a conventional four-seater light airplane, the wingspan is about 32 feet (9.75 meters), and the chord is about 5 feet (1.5 meters), giving the span-to-chord ratio of 6.4. The difference is so great!

The flying body is equipped with a 200 horse-power engine.



Outline of the Flying Body.

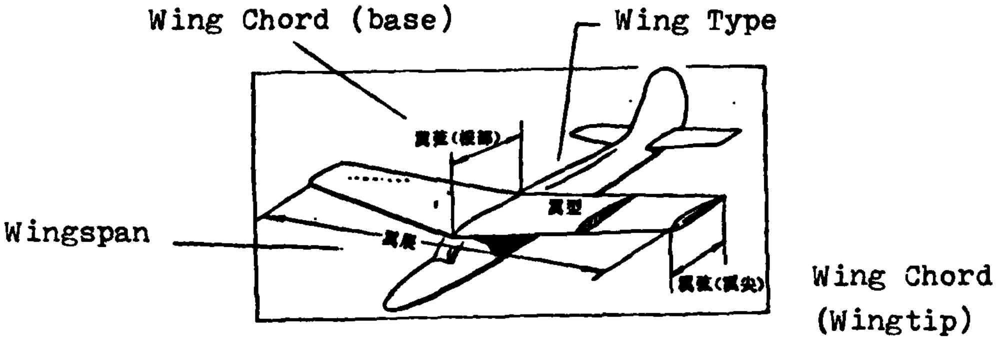
The engine drives a constant-speed triple-blade propeller to produce forward thrust for the aircraft. The operation of the flying body is very simple. It uses only a drive stick and a foot pedal for controlling the nose wheel and the yaw panels.

The construction of the flying body is also simple. There is no complicated curves and no tapered spanwise sections. The wings are extremely thin. Their thickness is 15 percent of the chord, much thinner than the wings in the ordinary airplanes.

Flying Characteristics

With the engine roaring, the flying body ran down the runway for 1200 feet (about 366 meters). Then the pilot yanked the drive stick back and the aircraft rapidly leaped into the air. With a speed of 75 miles (120.7 meters) per hour, the flying body climbed at a rate of 250 feet (76.2 meters) per minute. All these were rather unimpressive, since a light airplane with a 100 horse-power engine can climb much faster than that. Note that the horse power here is 100, only half of the efficiency of the flying body.

As the flying body ascended higher and higher, the air temperature dropped. Suddenly, there was a gust of wind blowing toward the aircraft. An airplane, especially a light



The wingspan, wing chord, and wing type in an airplane.

Outline of a modern wide-body passenger airplane.

passenger plane, flies with difficulties in gusty winds. Therefore, the weather stations in various regions watch for atmospheric changes in the flight paths, and direct airplanes to bypass any "reefs" for safe flying. The flying body, though a little shaky under the attack of the gusty wind, was unusually stable. It seemed to demonstrate that it was not like an untamed wild horse, but that it was as smooth as a train ride.

Finally, the flying body flew around the airport in a wide square pattern. In order to take a few good pictures, it was necessary to find sunny holes in the clouds. So, there was constant flight maneuvering. The pilot made several sharp turns. Once, he banked so steeply that he was practically inverted for an instant. These scary moments impressed us deeply, since there is no rudder on the flying body. The ordinary airplanes need rudders to correct for sideway yaws.

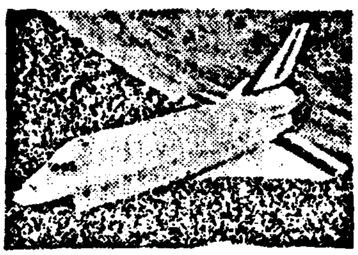
Why does the flying body possess these flight properties? First, its span-to-chord ratio is small, so that the aircraft is not sensitive to any change of center of gravity and is affected only slightly by gusty winds. Second, the vertical plates on both sides of the aircraft provide directional stability of the airplane and, like a wing-shaped knife, increase lift by preventing spanwise airflow that spills off wingtips. Further, the propeller's position was carefully planned. The propeller fans the air and makes it flow back rapidly over the center of the aircraft. This creates a good laminar flow, reduces friction, and increases lift. All these apparently improve the stability of the flying body at a low-speed flight condition. Under certain circumstances, a conventional airplane will spin and lose speed. But the flying body can fly with stability.

The fastest speed ever flown by the flying body was 150 miles (about 241 meters) per hour, rather inferior. The flying level at full-speed power was 107 miles (172 meters) per hour. The cruising speed was 95 miles (152.9 meters) per hour. It weighs 2150 pounds (about 975.2 kilograms), including the weight of the pilot and 25 gallons of fuel; it is slightly heavier than an ordinary airplane.

Conclusions

The flying body introduced here is not an aircraft that has been put into practical uses; nor is it a research prototype invested by an airplane manufacturer. It is merely a new type of aircraft designed and built by Sawyer, who is dedicated to space work. Sawyer is a flight control and electronics technician at the Flight Test Center of the U. S. National Aeronautics and Space Administration. He has studied lifting bodies that led to the space shuttle. He has flown the flying body that he designed for 16 hours.

From the description above, we can see that Sawyer's flying body has flight stability, good maneuverability, simple construction, low cost, and inexpensive maintenance. It has been reported that with the same wingspan, the flying body can carry a load 4.5 times that of an ordinary airplane.



Outline of a space shuttle (also called spacecraft).

There are two sides on a coin. The flying body has a small span-to-chord ratio, high drag to lift, and low climb rate which is characteristic of a high drag. Further, the body is relatively heavy.

It was not an accident that Sawyer designed and built this flying body. Starting with a simple 12-inch paper-panel glider to a 6-foot radio-controlled twine-engine airplane, he has built a four-seater unmanned aircraft.

What is Sawyer's next goal? Getting financing to build a

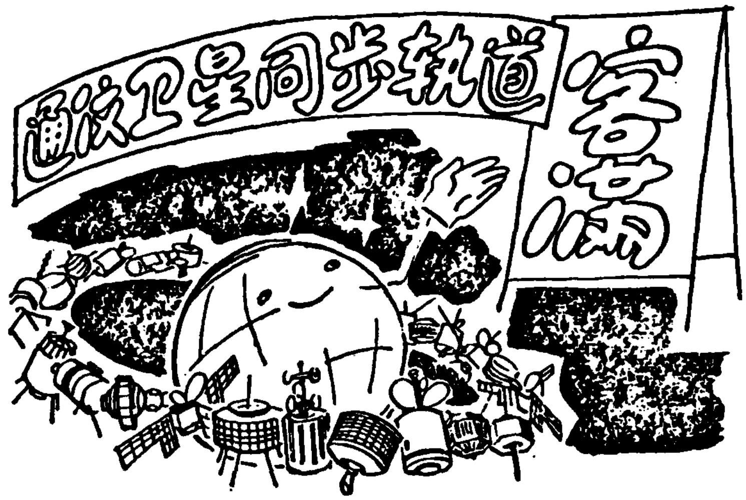
double-sized 36-foot (10.97 meters) prototype, to be powered by two turboprop engines. This aircraft would not have a nose section sticking out. The pilot and passengers would be completely enclosed in the flying body. The flight range would be 4000 to 5000 miles (6437 to 8047 meters).

Several aerodynamics experts gave Sawyer's flying body some favorable comments. They believed that this type of lifting body can be developed into a new kind of vertical take-off airplanes using the same propeller placement but incorporating high-lifting devices.

We believe that Sawyer is now researching an area that needs exploring. If his flying aircraft should proceed on the right track, then we will see some radically new airplanes in the next decade.

Translated and edited from Popular Science (U. S. A.)

Inserts by Chang Hsiao-li and Wen Cheng-cheng



No Vacancy on the Communications
Satellite Synchronous Orbit

Translated by Chu Te-po

In the space age today, there appears an unusual phenomenon: in a certain region of the wide-open outer space, "no vacancy" is declared.

The region of "no vacancy" is an orbital path about 35600 meters from the earth's equator. It is commonly called earth's synchronous orbit or earth's static orbit. This orbit is very important. A communications satellite launched to this orbit can maintain the same step as the earth. That is, when viewed from the earth, it will always look immobile relative to a point on earth. Hence, this type of satellite is called earth synchronous satellite or earth static satellite. The satellite may be used as a communications relay station, sending the signals it receives to the satellite's ground stations, which then amplify the signals and broadcast them to the users' receivers. According to the present engineering calculations, on this orbit 360 degrees around the earth, a satellite may be placed in every three degrees. The entire orbit can accommodate up to only 120 satellites. If this orbit is filled, any additionally launched satellite may be placed

only on top of this orbit if earth synchronization is to be maintained. This will be really difficult to do.

Communications satellites were commercialized in 1965. According to the latest statistics from the North American Air Defense Headquarter, there are 108 satellites that have been launched or about to be launched within a year, almost to the saturation number. Among these, 30 are from the U.S.A., 25 from the Soviet Union, and 2 from West Germany.

At present, the two technically advanced nations, the U.S.A. and the U.S.S.R., take advantange of their space technology and use satellite for television broadcasting, not only in their countries, but also spreading to the rest of the world. The orbit for launching of the communications satellites and the radio frequencies to be used are approaching the saturation point. Some Third-World countries have indicated their concern and grievance of this situation. Chimel, a legal consultant for Communications Satellites Company (U.S.A.), has said, "As far as the problem of congestion in the space orbit is concerned, the political conflicts will be greater than the geographic conflicts."

The World Administrative Radio Conference will be held in Geneva next year. The American delegation will be led by Robinson, a former member of the International Telecommunications Union. He is now a law professor at the University of Virginia. To soothe the grievance, he will have to resolve this problem of "no vacancy" in the conference.

Charge-coupled Devices

Chang Li-ch'ien

The entire equipment of an ordinary television camera takes up half of a carload. To put it into a satellite would be unthinkable. But a television camera that is constructed from charge-coupled devices will be compact and light. Having the size of an ordinary camera, it can be put into a satellite, and the television signals that it broadcasts can be received on ground. The modern fighter planes use firing-controlled radars. To eliminate interferences from ground echoes, an indicator for moving targets is required. A wave filter, made very delicate and versatile from the delay components of a charge-coupled device, can be used in the indication system for mobile targets. In space communications and signal transmission by remote control, the charge-coupled devices can be used to achieve multiplicity, speed, and secrecy. The charge-coupled devices can also be used as storage boxes for the computers in airplanes and satellites. A charge-coupled device, abbreviated CCD, is a new type of semiconductor. It first appeared in 1970. In only a few years, due to its wide applications, simple construction, high degree of integration, minimal deterioration, and fast response, it is widely used in satellites, aviation, navigation, radar, communications, television, medicine, meteorology, and commerce. We believe that it is an important breakthrough in the semiconductor

technology since the development of MOS integrated circuits. It is another great development following the large-scale integrated circuitries.

The Simple Working Principles

A charge-coupled device is made by growing a thin layer of insulating silicon dioxide (SiO_2) on the surface of a P-type or N-type silicon semiconductor lined chip. The layer thickness is 1000 to 2000 Angstroms. Then, using the light-etching technique, a layer of metallic aluminum electrodes, aligned less than 3 micrometers apart, is formed on the silicon dioxide surface, making a structure of metal-silicon dioxide-semiconductor. This is the construction method of a charge-coupled device, as shown in Fig. 1.

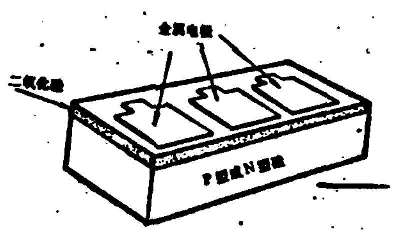


Fig. 1. A schematic diagram of a charge-coupled device.

If a positive polarity is induced on the metallic electrodes in the P-type silicon semiconductor lined chip of a charge-coupled device, as shown in Fig. 2, then the positive charges--vacant holes, on the surface of the P-type silicon below the electrodes, under the electric field, will be pushed away from the silicon surface, creating a depleted layer, which is called "potential barrier". The higher the potential, the thicker the depletion layer. Positive charges will have difficulties

to go through the depletion layer. But to the few carrier ions -- negatively charged electrons, this region is like a deep well, which is called "potential well". A negative electron fallen into the potential well will not readily come out by itself. If different positive polarities are induced on two adjacent electrodes, then two potential wells of unequal sizes will result. Since the distance between the two electrodes is very small, when the potential wells are connected, negative electrons will flow from the lower to the higher potential well. If electrons represent signals, then the flow of electrons from one potential well to another represents transmission of electrical signals from one place to another. This phenomenon is called charge coupling, or charge transfer.

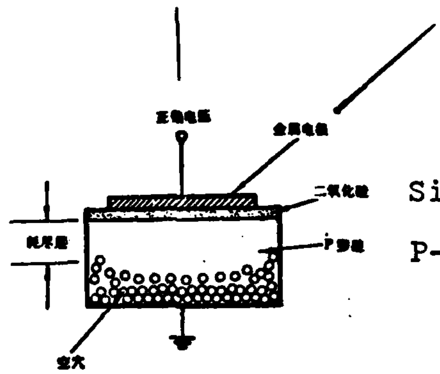


Fig. 2. A charge-coupled device with positive polarity.

In Fig. 3 (upper part), three different phases (120 degrees out of phase) of pulse voltages, ϕ_1, ϕ_2, ϕ_3, are induced separately on the three adjacent electrodes in a charge-coupled device. These voltages are called timing pulse voltages. At time t_1, ϕ_1 is positive, and electrons will fall into the potential well below electrode 1, as shown in Fig. 3 (first from left). At time t_2, ϕ_2 rises, electrode 2 produces a potential well below. However, ϕ_1 has not fallen at this time. Hence, the electrons below electrode 1 will move to electrode 2 below, as shown in Fig. 3 (second from left). At time t_3, ϕ_1 has fallen, ϕ_2 rises, and all the electrons will move toward electrode 2, as shown in Fig. 3 (third from left). At time t_4, likewise, the electrons will move to electrode 3 below, as shown in Fig. 3 (fourth from left). After one cycle T, at time t_5, the electrons will move to a fourth electrode below, and new electrons will be transfered to electrode 1. In this way,

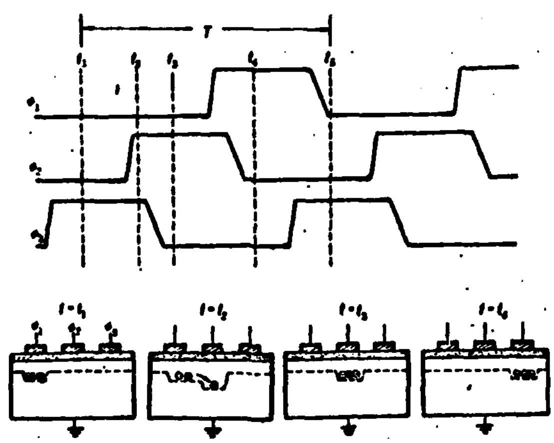


Fig. 3. Diagram of the principle of a charge-coupled device.

bundles of electrons move from one electrode to another, representing transmission of signals from one end to another. This is the principle of signal transmission in a charge-coupled device. Here, we use three phases of timing pulses. Two or four phases may also be used.

Input and Output of Signals

How are signals delivered to a charge-coupled device? Refer to Fig. 4. Make an N+ diffusion region in the semiconductor of a P-type silicon lined chip, using the diffusion method, and form a reverse polarity diode. Between the reverse polarity diode and the first transfer gate electrode, construct an input gate electrode and use it to control the input signals. The input signals enter through separate direct current capacitors. We add a control pulse with the

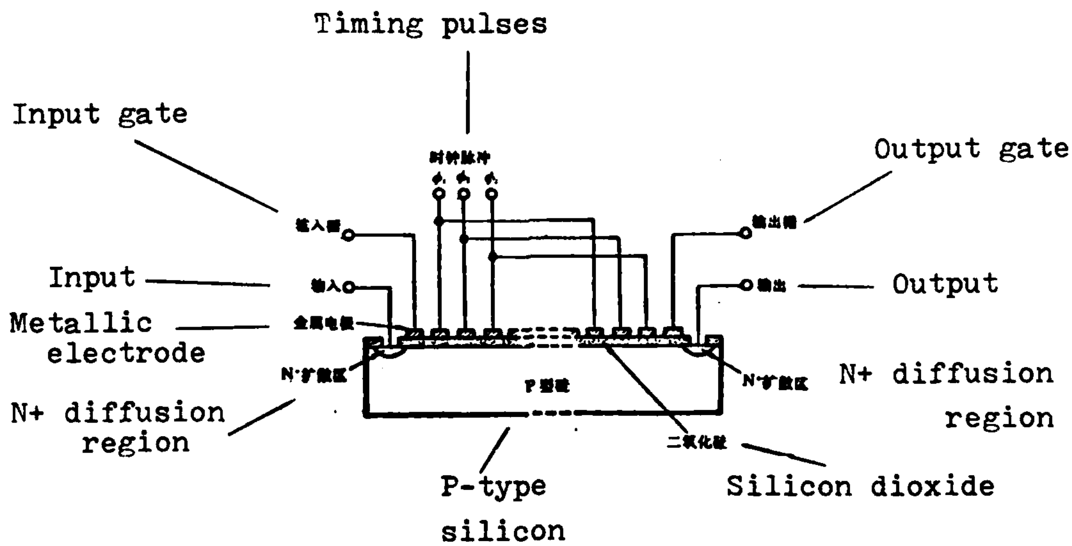


Fig. 4. Signal input and output in a charge-coupled device.

same frequency and phase as ϕ_1 to the input gate electrode. When ϕ_1 rises, the input gate electrode becomes positive with respect to the input diode, and thus the signals enter through the input gate potential well and into the ϕ_1 potential well. Under the control of the input gate, the signals flow into the charge-coupled device in bundles. The stronger are the signals, the greater are the input signal charges. If the signals consist of very narrow pulses, then a pile of charges will enter. Simulated signals will result in groups of charges of different sizes, but with equal sampling and timing frequencies.

Signal output is exactly the opposite to signal input. When bundles of charges move to the last transfer electrode potential well, they flow through the output gate potential well and are collected in the reverse polarity diode. The latter receives the signals and, after amplification, send them out. The amplifier is integrated in the silicon chip of the charge-coupled device.

The Characteristics of a Charge-coupled Device

In the charge-coupled devices discussed above, the signal charges, under the action of the timing pulses, flow in bundles through the electrode potential wells from one end to another. This transmission method is like the series-displacement storage in a number circuit. Hence, a charge-coupled device may be used as a displacement storage. There is a time delay when signals flow through a charge-coupled device. Thus, a charge-coupled device can also be used as a delay component. The delay time depends on the number of transfer electrodes and the frequency of the timing pulses. As the number of transfer electrodes in a component is fixed, varying the timing pulse frequencies can easily change the delay time. This is some-

thing that an ordinary delay component cannot do. It is also an outstanding feature in using a charge-coupled device as a delay component.

In a charge-coupled device with triple-phase timing pulses, the charges flow through the positions of three electrodes in one pulsing cycle. For number signals, the three phases represent one unit. The transfer time required for one unit is 1/f (f being the frequency of the timing pulses). The time required for N units in a charge-coupled device is N/f. Therefore, varying the timing pulse frequencies can change the transfer rate of a number base. Because a charge-coupled device possesses this feature, it can be used for signal amplification and contraction.

Transferring simulated signals by a charge-coupled device uses timing frequencies for sampling. Continuous signals are converted into discrete charge bundles of different sizes for transferring. The output signal is a divergence value. Through a low-pass wave filter, it will return to become a simulated signal. If no distortion of the signal is required, then the sampling frequency should be high and the pass frequency band should be wide. Since we always want less distortion of the wave shape, this means we would hope that the pass frequency band will be wide. The highest pass frequency band in a charge-coupled device can get up to one thousand trillion hertz. A frequency band that wide is impossible for the ordinary delay components to achieve.

What are the applications of charge-coupled devices? We will discuss them in detail next time.

Inserts by Chang Tseng-yi

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